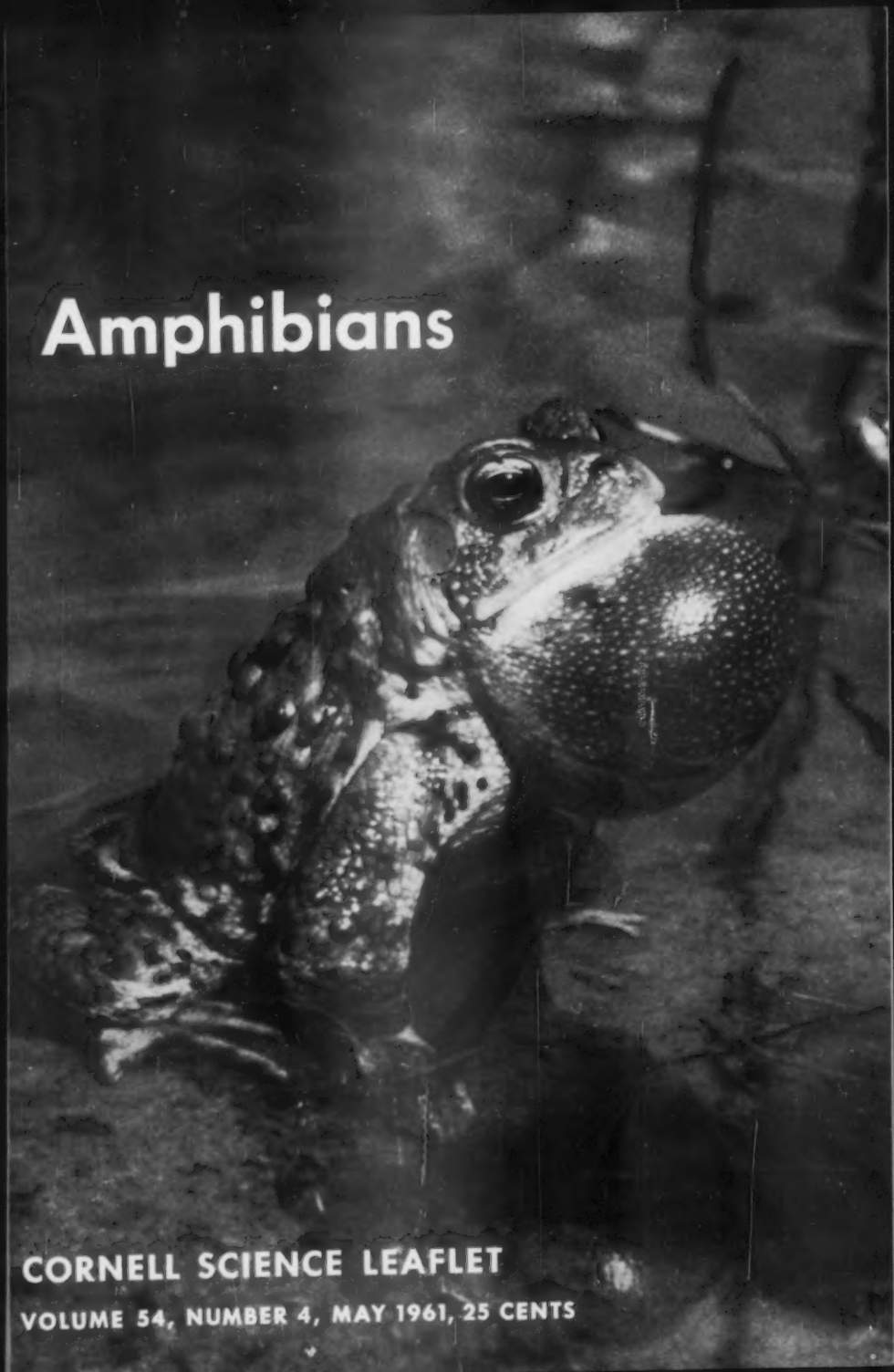
Amphibians



CORNELL SCIENCE LEAFLET

VOLUME 54, NUMBER 4, MAY 1961, 25 CENTS

CORNELL SCIENCE LEAFLET

Volume 54, Number 4, 25 cents, May 1961

Published four times yearly by the New York State College of Agriculture, a unit of the State University, at Cornell University, Ithaca, New York

Acknowledgement

The photographs on pages 5, 20, and 23 are from the Photo Science Service, Cornell University. Professor Richard B. Fischer supplied the photograph on page 4 and Professor Emeritus A. H. Wright supplied the photograph on page 11. All other photographs are by the author.

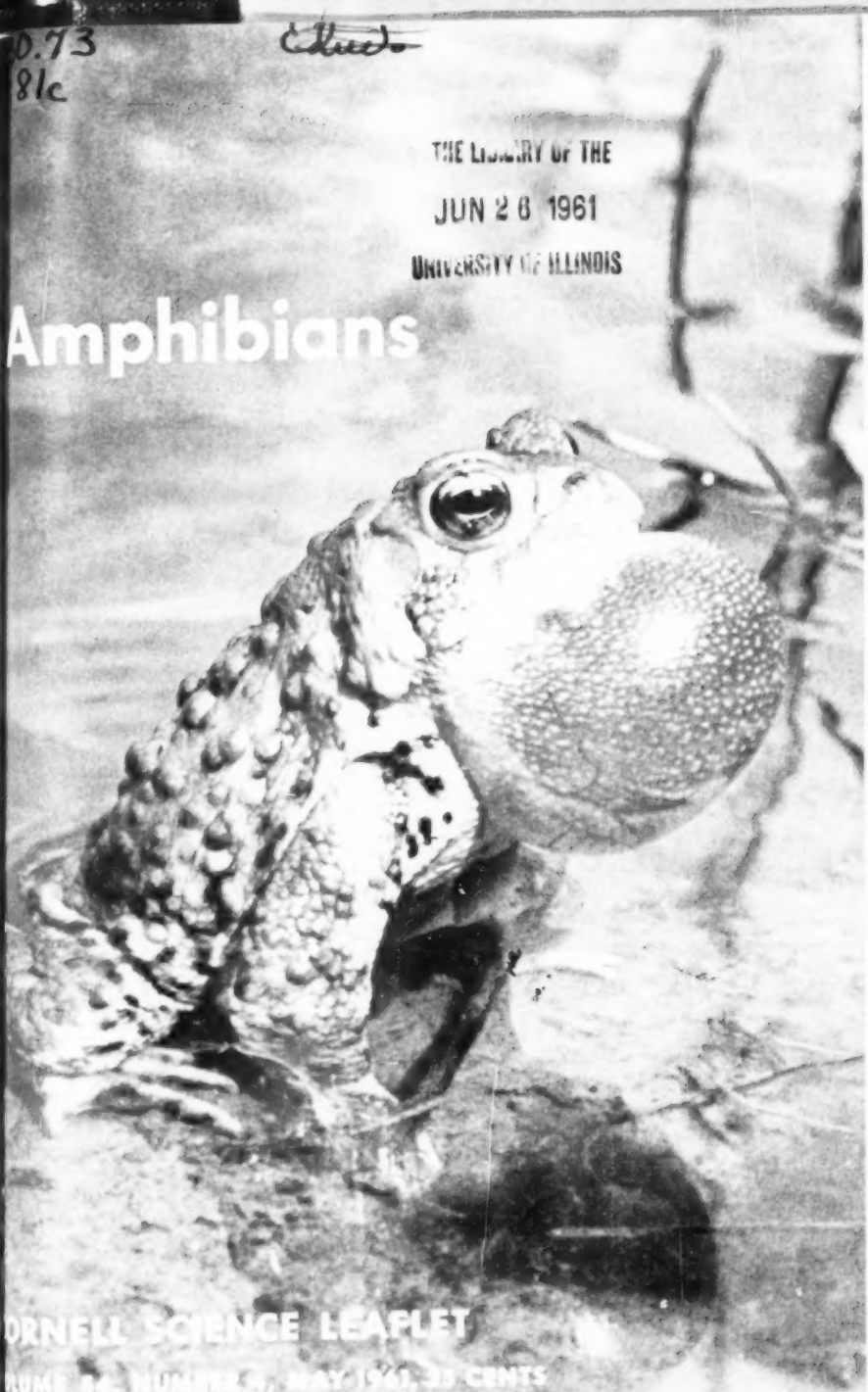
Cover: An American toad, *Bufo americanus*, singing in a pond near Ithaca.

Second-class postage paid at Ithaca, New York

0.73
81c

THE LIBRARY OF THE
JUN 26 1961
UNIVERSITY OF ILLINOIS

Amphibians



ORNELL SCIENCE LEAFLET
VOLUME [illegible], NUMBER [illegible], MAY, 1961, 25 CENTS

CORNELL SCIENCE LEAFLET

Volume 54, Number 4, 25 cents, May 1961

Published four times yearly by the New York State College of Agriculture, a unit of the State University, at Cornell University, Ithaca, New York

Acknowledgement

The photographs on pages 5, 20, and 23 are from the Photo Science Service, Cornell University. Professor Richard B. Fischer supplied the photograph on page 4 and Professor Emeritus A. H. Wright supplied the photograph on page 11. All other photographs are by the author.

Cover: An American toad, *Bufo americanus*, singing in a pond near Ithaca.

Second-class postage paid at Ithaca, New York

Amphibians

VERNE N. ROCKCASTLE

Do toads give you warts? Does it ever rain frogs? Are salamanders the same as lizards? Children sometimes ask these questions in all seriousness. None of the answers is "yes," but amphibians do have some interesting and peculiar characteristics that you can see and study.

Amphibians (frogs, toads and salamanders) are common in most temperate and tropical countries where the climate is moist. They usually prefer cool shade to the sun because they like their skins to stay moist.

Some amphibians may look ugly but sing beautiful songs. Others that have some measure of beauty make almost no sound. Some are very secretive, creeping about only at night under wet leaves and damp wood. Others jump about in broad daylight where it is easy to see them. At least one lives where daylight never occurs.

A few amphibians have commercial value. On farms in the South, big bullfrogs are raised for market because their legs are a prized dish. Some frogs are used for bait, or for laboratory studies by zoology students. Large salamanders also are used in laboratories. Mostly, however, amphibians are just enjoyable animals—harmless, interesting creatures that you can study at your leisure almost any time between early spring and late fall in most parts of the United States, except the arid Southwest.

WHAT IS AN AMPHIBIAN?

Amphibians have skeletons as do fishes, lizards, birds and cats, but there the resemblance stops. Their moist, usually smooth skins, gilled young, and clawless feet make them different from all their backboned relatives.

Like fishes and reptiles, amphibians are cold-blooded. This does not mean that their blood is cold, but that they have no means of regulating its temperature the way birds and mammals can. An amphibian put in a cool place becomes cool. In a warm place it becomes warm. If an amphibian feels clammy, it may

Compare the characteristics of this reptile, a collared lizard, with those of the amphibian shown on the opposite page.

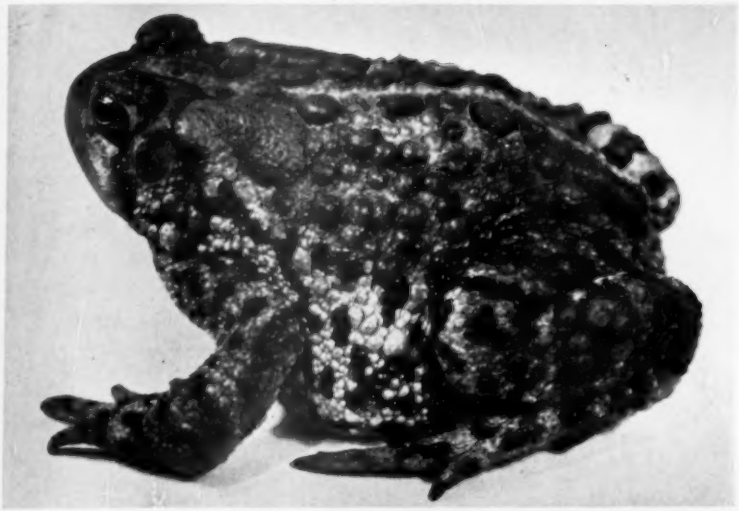
be because it was in a cool, moist place when you found it.

Amphibians usually spend the early part of their lives in water as gilled larvae (tadpoles). As adults, they usually live on land and breathe by means of lungs. Not all amphibians live on land as adults, but even those that remain in or return to the water usually breathe by means of lungs. You will read about some exceptions to this general rule, however.

Because many persons confuse amphibians and reptiles, the following table will help to show the main differences between the two groups:

	Amphibians	Reptiles
Skin:	Smooth, moist	Scaly, dry
Eggs:	Laid in water or moist places	Laid in soil or debris, not in water
Breathing:	By gills when young; usually by lungs later	By lungs only
Feet:	Toes without claws	Toes have claws
Ears:	No external opening	Some have external opening

Scientists recognize three main living groups or *orders* of amphibians. One is called the Anura (a-new′rah). The name comes from the words *ura*, meaning tail, and *an*, meaning not, so *An-ura* means without a tail. This order of amphibians includes



Compare the characteristics of this toad with those of the collared lizard shown on the opposite page. How many differences can you find?

the frogs and toads, because they ordinarily have no tails as adults. Another order is called the Urodela (yew-ro-de'lah). This name comes from the words *ura*, meaning tail, and *delos* meaning visible. *Urodela* means visible tails. This order includes the salamanders, of which there are more species in the United States than in any other country in the world. The third order is a small one, and has no representatives in either the United States or Canada. Its only members are blind and legless creatures that look like worms.

Amphibians appeared long before man, and even before the first reptiles. The earliest amphibians left their tracks in sand in Pennsylvania over 300 million years ago! They were strange creatures, with bony plates protecting their heads both on top and underneath. Some were nearly ten feet long, but most were considerably smaller.

With the appearance of reptiles and their fantastic rise to animal power about 100 million years later, the amphibians declined in size and in variety, until today only scaleless, small amphibians remain. These remnants of a once larger group, however, have successfully taken up quarters in lakes, streams, woods, and meadows where they are an important part of the moistland fauna.

FROGS AND TOADS

CHARACTERISTICS

Skin

The skin of frogs and toads is scaleless, as it is in all other amphibians. In toads, there are "warts" or glands in the skin that help to distinguish them from frogs. These glands are especially noticeable on the common toad, but handling them will not cause warts on the hands, despite some persons' insistence that this will happen. Frogs' feet also are more fully webbed than toads' feet.

The glands in the skin of toads and some frogs do give off a substance that can be most irritating to the mucous membranes of the mouth and eyes, however. This is about the only effective means of protection that some of the slower moving and mild-mannered amphibians have. Dogs and cats that pick up toads in their mouths often drop them in distaste. Other animals, however, seem not to be irritated at all by the glandular secretions from the warty skin. Hog-nosed snakes, for example, actually seem to prefer toads to other kinds of food.

For some animals, such as other frogs, the glandular secretions may be poisonous. Pickerel frogs have been known to cause the death of other frogs kept in the same container. One scientist tells of South American Indians tipping their poison arrows with the mucous from a toad. Such accounts, however intriguing, should not deter any interested person from handling our native frogs and toads. All are harmless to the hands.

Although all frogs and toads have lungs and use them for breathing, their lungs are not nearly so efficient as ours. The lungs of birds and mammals have countless pockets and folds to increase the surface in contact with the air that enters them, but the lungs of many frogs and toads are merely simple sacs, with little or no wrinkling to increase their surface. For this reason, their skin often is used to supplement the lungs in breathing.

When an amphibian's skin membrane is moist, gases such as oxygen can diffuse through it readily. If it dries, diffusion is retarded or stopped altogether. For this reason, amphibians must moisten their skins from time to time, either by submerging themselves in water or by staying close to moist earth until they absorb sufficient water. In dry weather, toads often burrow into moist earth and remain there until it rains.

Tree frogs and toads normally have drier skins than the bullfrog and the green frog. The lungs of tree frogs and toads also have more folds and therefore more surface for breathing. It would be unfortunate if tree frogs, who leave the water early in spring and do not return until fall, needed moist skins to survive. Dew and rain help, of course, but some amphibians need the moisture more than others.

This tree frog is almost invisible against the tree bark on which it rests.

The color of toads and frogs varies greatly from species to species. Green is a common color for pond and meadow frogs. Tree frogs, however, can change their colors to approximate the background on which they rest. Some tree frogs soon look green when placed on grass. Placed on grey tree bark, they lose their green color and turn greyish. This ability to change color is caused by small pigment cells in the lower layers of the skin. When the pigment cells expand, the skin takes on one color; when they contract, the skin appears to be a different color.

In addition to their limited ability to change color, there is also natural variation in color among frogs and toads. Some are naturally darker than others, and cannot become much lighter even on white paper.

Color markings are distinctive for some species of frogs and toads. The square dots along the back of the pickerel frog are in two distinct rows. The leopard frog, which strongly resembles the pickerel frog, has two rows of dots, but they are rounded. On the underside of its thighs, the meadow frog is creamy white, but the pickerel frog is bright yellow-orange.

The two rows of round spots down the back of the meadow frog help to distinguish it from the pickerel frog which it resembles. In grassy places, both frogs are well concealed.

The lighter color underneath, and the darker color on the back of most frogs and toads, is sometimes explained as being protective adaptation to the environment. A green frog among the water weeds, for example, would be difficult to detect. Seen from beneath when it is floating on the water, the light colored underparts may look like the sky above. This may be pure conjecture, however, because only a fish or a turtle knows what a frog looks like to a fish or a turtle.

The skin of all frogs and toads is shed periodically, although most persons will never see the process, nor the shed skin. The shedding creatures are very secretive, and soon after the shedding is complete, they swallow the old skin!

Shedding the skin is a somewhat comical process. A toad, for example, will hump its back and appear to blow itself up as the skin splits along its back and belly. With seemingly awkward humpings and rubbing of the hind legs, the toad slowly slips the skin over its head just as you might bend over and attempt to remove a coat without the aid of your hands. Finally the skin passes

over the head, is freed, and eaten. The whole process may take only a few minutes, and may be repeated as often as two or three times a month, although once a month is more usual.

If you can salvage a shed skin, save it for examination. Notice how thin and transparent it is. The shed skin is nothing at all like the stout, colorfully pigmented layer beneath it.

When the tadpoles (larvae) of the frogs and toads are small, they look uniformly black or dark brown. As they become larger, some show color changes. The tadpoles of the bullfrog become olive-brown, mottled with specks of black. Leopard frog tadpoles change from dark brown to almost an olive color, as do green frog tadpoles. Most tadpoles, however, do not become brightly colored; they remain dark-colored like the debris-covered pond or stream bottom that is their birthplace.

Mouth

The mouths of frogs and toads serve a special function in breathing. Although we can breathe with our mouths closed or open, frogs and toads can breathe only with their mouths *closed*. The muscles of their mouths must do the work that our ribs and diaphragm do in breathing.

A frog's nostrils open into its mouth. The nostrils are provided with valves that open or close completely. When a frog breathes, it first opens its nostrils, closes the passageway to the lungs, and then lowers the floor of the mouth. Air pushes through the nostrils into the mouth cavity.

Then the frog closes the nostrils, opens the passageway to the lungs, and raises the floor of the mouth. Air cannot escape through the nostrils, so it is forced into the lungs. When you see a frog or a toad moving the floor of its mouth up and down, it is actually breathing. If its mouth were open, raising and lowering the floor of the mouth would send air in and out of the mouth, but not to the lungs.

Once a frog and a praying mantis occupied the same cage. The frog leaped at and caught the praying mantis, but instead of getting the whole insect in its mouth it got only the head. The praying mantis used its powerful front legs to keep from being swallowed further. The frog, on the other hand, could not breathe with its mouth pried apart by the head and thorax of the mantis. Finally, the two separated, seeming to call the struggle a draw.

The fleshy tongue of frogs and toads is an efficient organ for catching insect food. The top of the tongue is sticky. The tongue itself is connected at the front end instead of at the back like yours. When the frog or toad senses an insect nearby, the mouth opens and the tongue flips up and out to wrap around the insect and snap it back into the mouth. The whole process takes but a fraction of a second. In the mature American toad, the tongue may reach out a full two inches to snap up a juicy fly.

Once the prey is in the mouth, a seemingly difficult swallowing process begins. The eyes of the frog or toad are retracted into its head during the swallowing process. The eyelids close and it appears that the animal is trying to swallow something much too large. Then suddenly the eyelids open, the eyes are back in position, and the food is down. Pulling the eyes in seems to be an essential part of swallowing large prey.

Tiny teeth often ring the upper jaw in frogs, or teeth may be lacking in both jaws as in the toads. These tiny teeth are not used for chewing. Their only use is to hold slippery food. In bullfrogs, the teeth may serve to keep an earthworm from slipping away. When frogs and toads catch insects, they do not depend upon their teeth either for holding or crushing the prey.

Eyes

Long ago, William Shakespeare recognized the beauty of the eye of the toad when he wrote ". . . the toad, ugly and venemous, wears yet a precious jewel in its head."

The beauty of the toad's eye lies in the combination of the jet black pupil and golden iris. The flecks of gold in the iris, together with the more brilliant gold color of the muscle next to the pupil, make a bit of beauty that one would never suspect on such a warty animal.

In most frogs and toads the pupil is elliptical and horizontal. In the spadefoot toad it is vertical, and in some other tree frogs it may be even three- or four-cornered.

The eyes of most frogs and toads are set up on the head like little turrets, where they are in a position to watch for food, especially when their owner is submerged in water or in soil. As long as nostrils and eyes remain above water, these amphibians can remain motionless yet alert to any movement that means food or danger.

The retina in the eyes of frogs and toads is similar to our own; both rods and cones—the visual cells —are present. The structure of these cells is somewhat different from ours, but they perform similar functions of detecting color and form in bright and dim lights.

Unlike the eyes of man, the lenses of frogs' and toads' eyes do not change shape to accommodate near and far objects. Instead, they are like a camera lens that is shifted in and out to focus on objects at varying distances. The common or American toad can focus on a distant object at one instant, then in a twinkling, on a moving insect close by.

Frogs and toads apparently cannot see objects that do not move. A fly is usually free from harm until it begins to move; then it is in real danger of being snapped up. This fact is useful in trying to feed bits of meat to toads and frogs. Merely placing a bit of meat in a terrarium is likely to attract no attention at all, but the animal may seize and swallow food that is tied to a string and moved slowly back and forth.

The eyes of frogs and toads are so large in comparison to their shallow skulls, that the thin, strong, lining of the mouth cavity is just under the eyeball. When a piece of food is swallowed, frogs and toads pull their eyes back into their heads. In this way, the eyes probably help push food to the back of the throat where it can be swallowed.

Ears

The ears of frogs and toads show only as round or oval tympanums (drumheads) just behind the eyes. Males have larger ones than females. In the bullfrog, they are larger than the eyes. The tympanum covers the canal leading to the inner ear, which is the center for both sound and balance. Semi-circular canals, similar to those in humans, perform the functions of balance. These canals apparently are sensitive and effective, because frogs and toads respond quickly to changes in their position.

Hearing in toads and frogs is acute. If you try to approach a chorus of peepers, their songs stop abruptly, showing how easily they detect strange noises. After the strange sounds cease, they soon react to the songs of more distant frogs and begin their chorus again. Voices do not bother singing amphibians so much as footsteps, a cracking twig, or a splash in the water. Even a loud bell seems to have little effect on their singing, except to make them sing louder.

Can you see the large tympanum or "drumhead" behind the eye of this bullfrog? In the females it is slightly smaller.

Voice

The American toad and the spring peeper are two of the best singers at ponds and marshes in spring. Toads will sing in the daytime, and seem to be undisturbed by watchers. When you hear the high-pitched, sustained trill of toads in April or May, follow the song to the water where the males are singing. If you approach slowly, you may witness the whole process of courtship and reproduction (page 13).

Peepers are best observed at night with the aid of a flashlight. Approach them as stealthily as you can until you think you are within a few feet of one. Then turn on the flashlight and see if you can find it in the beam. You may have difficulty locating a peeper at first, because they are so small and blend so well with their background. Sometimes one can sing for minutes within two feet of an observer, and still not be seen.

This tree frog, like peepers and cricket frogs, can climb right up glass with the help of sticky discs on its toes.

Both males and females have vocal apparatus, but only the males can sing well and loud. Their songs are usually to call females and other males to the water where mating and egg-laying take place.

In the passageway that connects the mouth with the lungs of frogs and toads, two folds form the vocal cords. When the animal fills its lungs with air, then closes the nostrils and mouth, the air can be swished back and forth from mouth to lungs. This makes the vocal cords vibrate to produce the singing sound.

In addition to swishing the air back and forth rapidly, the males usually inflate either the floor of the mouth (toads and tree frogs), or pouches at the side of the head (bullfrog, green frog and meadow frogs) to serve as resonating chambers. These inflated chambers act much as a sounding board on a piano, or as the body of a violin. Because the animals sing with their mouths and nostrils closed, they also can sing under water. Can a human sing or talk with closed mouth and nostrils?

The picture on the cover shows an American toad singing, with its throat distended to the size of a golf ball. This toad trilled its high-pitched song for half a minute before relaxing the resonating membrane. In a minute or two it began again. All over the pond other males were singing. Around the edge of the pond new arrivals were leaping far more than is usual for toads—all hurrying to get to the water and join in the chorus.

The "Jung" of the male green frog can be heard on warm evenings from early spring to August. Although most active in late spring during the breeding season, peepers can be heard well into early summer, and occasionally as late as November.

Tree frogs sing during the mating season in spring or early summer, but they also sing from trees and shrubs on warm, moist evenings in the summer. Wood frogs, on the other hand, seldom sing after the mating season in early spring.

The Cornell University Press in Ithaca, New York, has a long-playing record of songs of frogs and toads. A record of this kind, played before you visit a pond during the breeding season, will help you identify and

appreciate the kinds of amphibian songs that you hear.

Listen for the whistle-clear peeper song, the similar but stridulant song of the swamp cricket frog, the sustained trill of the American toad, or the quack-like croak of the wood frog. Later on you may hear the "jung" of the green frog or the drawn-out, "jug-o-rummm" of the bullfrog. When you get to know them, the songs of frogs and toads are as enjoyable as those of birds.

HABITS OF FROGS AND TOADS

Courtship and reproduction

The American toad is one of the easiest amphibians to observe during its reproduction. The males sing lustily, and are not much disturbed by watchers. When females have arrived at a pond or marsh in response to the males' calling, the males soon find them. The male toad's thumb enlarges during the breeding season, and with this and

When mating, the male toad holds the female tightly with its front legs. Can you see the strings of eggs in this picture?

Freshly laid toads' eggs are in two strings — one from each ovary. The jelly-like strings swell soon after being deposited in the water.

his powerful forelegs, he tightly clasps the female just behind her front legs as shown. The urge to clasp an object about the size of a female toad is strong. The males have been seen to clasp even a teasel head at this time! Sometimes a male will inadvertently clasp another male, but at this the clasped male croaks, and the clasper immediately lets go. Females never seem to croak when they are clasped.

Occasionally more than one male toad will try to clasp a female during mating. If the combined weight of two struggling males is more than a female can carry, she may have difficulty keeping her nostrils above water. Females have been known to be drowned by the struggles of more than one male to mate with her.

Soon after being clasped, the female will begin to lay her eggs in two strings, one from each ovary, trailing out behind her as she swims and kicks her way among the weeds of the water. The male deposits sperm on the eggs as they are laid. Ordinarily from 5,000 to 10,000 eggs are laid by an adult female toad. As many as 200 to 300 eggs are laid in one location, then the female may move a short distance before continuing.

Toad's eggs look like tiny black beads in a string of jelly. The eggs swell considerably after being in the water a short time. In this gelatinous string, the black eggs begin to develop, and in a few days hatch into tiny, gilled larvae that twitch their way across the pond bottom.

Frogs' egg-laying habits are similar to those of toads, except that their eggs are usually laid in masses instead of strings. Some frogs, such as the tiny cricket frogs, may lay only one egg or a few at a time, moving from one nearby location to another as each group of eggs is deposited. In the picture at the right, meadow frogs had laid eggs in a one-acre pond in such masses that one could hardly step without being in eggs! Of these thousands and thousands of eggs, probably only a hundred or two would survive, and perhaps only half of these return to the pond to lay eggs the following year.

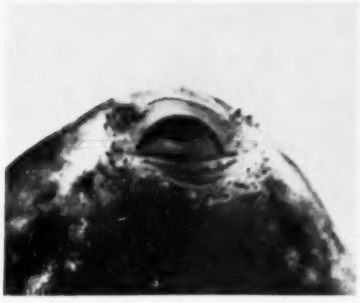
The surface of this pond was nearly half covered with the egg masses of dozens of meadow frogs.

Some South American tree frogs deposit their eggs on the backs of the males, then the males carry them to a stream where they complete their transformation to adults. Other South American tree frogs carry the eggs in sacs on their backs, where they hatch and complete part of their metamorphosis. These are interesting exceptions to the rule that frogs and toads lay their eggs in water.

Growth and metamorphosis

As the tadpoles grow inside their gelatinous containers, they resemble tiny commas. After a few days, you can see them twitch inside the egg membrane, and soon they emerge as black larvae. They settle to the bottom of the pond or to some debris where they remain almost motionless, except for a wiggle now and then. Gradually the head assumes its characteristic oval shape, the movements become more frequent, and in a few more days the larvae look and act like the tadpoles with which children are familiar.

Tadpoles are usually omnivorous. Their lips are rimmed with scrapers, sometimes in more than one row. With these they scrape off and eat algae and other bits of vegetation that grow on submerged objects. They also eat small animals that



The mouth of a toad tadpole. Can you see the tiny rows of scrapers just below the horny jaws? They scrape food from plants and from the sides of your aquarium.

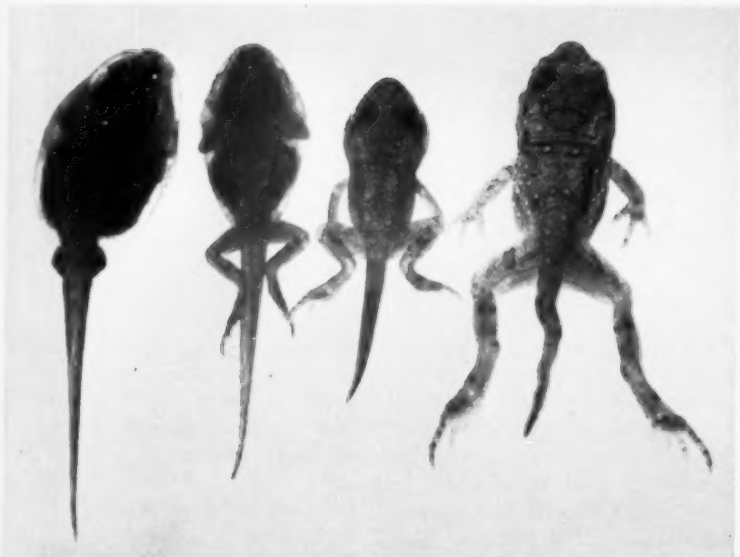
abound in the pond waters, as well as dead animal matter that settles to the pond bottom.

Animals that eat plant material usually need a longer digestive tract than those that subsist solely on animal matter. Tadpoles of frogs and toads are no exception. The picture shows the coiled intestine that you can see in almost any nearly full grown tadpole, especially toads. The stomach wall is so thin that you can sometimes see the outline of the intestine of a tadpole as it clings to the side of an aquarium.

Early in summer, as toad tadpoles and the tadpoles of most frogs mature, they begin to grow legs. The hind legs appear before the front legs. Seen first as little buds near the base of the tail, the hind legs grow rapidly, and soon you can see toes on them. Later, the front legs appear, but in doing so they cause an important change in the tadpole.

Tadpoles of frogs and toads have internal gills. The tadpoles take water in through their mouths, pass it over the gills, and then out through a pore in the left side of the head.

The coiled intestine of this toad tadpole is clearly visible right through its skin. Plant eaters usually have longer intestines than meat eaters. (Each mark is a millimeter)



Four stages in the growth of a toad. At the left you can see the hind legs just beginning on the tadpole. The next stage shows the front legs which have not yet broken through the skin. In which stage(s) are lungs used? After about a year on land, this red eft returns to water, even though it has lost its gills. It remains in or near water for the rest of its life as a newt.

If this pore were blocked, the gills could not function.

When the front legs develop, the right front leg grows slightly faster than the left. Finally, the left front leg pushes out through the pore and blocks off the water circulating through it. This forces the tadpole to discontinue the use of its gills and begin to rely on its newly formed lungs. More and more it comes to the edge of the pond to sit and breathe. Its tail grows smaller and its legs stronger, until at last it leaves the water except for occasional visits, egg-laying and hibernating.

In bullfrogs and green frogs, however, the tadpoles remain in the water all through the first year and only when the second summer arrives do they begin their metamorphosis. Children are often disappointed when they catch tadpoles in spring and find when school is recessed that they still have not begun the change to adults.

For school use, toads are perhaps the best tailless amphibians to study,

because their metamorphosis is completed by the time school recesses for summer. By collecting a few eggs in a string in April or May, the tadpoles will have grown their legs and probably left the water by mid- or late June.

Feeding habits

Frogs and toads are so voracious that they will eat almost anything that is small and moves. Because insects are so numerous and are especially abundant around waterways, they form the bulk of the diet of tailless amphibians. Even small minnows, snakes, and occasionally members of their own species are eaten by large frogs. Toads are more discriminating, and seem not to be attracted by small toads. They also disdain insects that appear too large to be eaten.

Sometimes frogs and toads will watch a moving insect carefully, turning their bodies toward the prey, stopping as the insect stops, then striking like lightning when the insect resumes its movements. Occasionally plants will drop seeds or fruits that roll or move when they strike the ground, drawing the attention of a frog or toad nearby. One scientist watched a toad eating mulberries that fell to the ground and rolled along. Mostly, however, frogs and toads are strictly carnivorous.

Hibernation

In New York State, all frogs and toads hibernate for the winter. Usually they choose a pond or a woods in which to spend the winter. In autumn, as the weather turns colder, most frogs begin arriving at a pond. They spend a few days near the shore, then move toward the bottom of the pond where they bury themselves in the mud and stay until spring. Their skins now take care of their breathing, for their metabolism has slowed to only a fraction of what it was during the summer.

Toads sometimes burrow in the soil beneath a log, under a stone, or along the foundation of a building. There, protected by soil and debris such as leaves and grass, they spend the cold, wintry days.

Peculiar habits of frogs and toads

Like most other animals, frogs and toads are fun to observe. Occasionally, one shows signs of an individual personality. For example, there was a huge bullfrog at a summer camp in the Adirondacks of New York State to whom the children gave the name Caesar. Caesar would come out each evening at the end of the dock and bellow forth his "jug-o-rum." He was as voracious as he was fearless, snapping up grasshoppers tossed toward his hiding place near the edge of the dock. At night, when approached with a flashlight, he would wait until the flashlight was inches away, then leap toward it with open mouth.

A tree frog, captured in a shrub at the edge of a pond during the breeding season, sang all the time it was held captive in a milk bottle.

The resonance of the milk bottle made its song sound a little odd, but the frog apparently liked it. When it was removed from the milk bottle for some pictures, it promptly ceased singing.

Snakes, especially garter snakes and water snakes, like to eat frogs that they find around wet meadows, ponds and streams. A large bullfrog or toad, however, may turn the tables on the snakes and eat small snakes that it finds. A bullfrog has been known to leap at a small bird passing over its hiding place in the water.

In a terrarium, a big toad may dominate all the other animal life. If two worms are put in to feed a large and a small toad, the larger toad may eat his own and the worm of the smaller toad besides. In a pond, a large frog makes known its territorial rights, chasing out intruders with aggressive jumps and croaks.

SALAMANDERS

CHARACTERISTICS

Salamanders, sometimes called lizards by those who do not know the difference, are unlike frogs and toads because they have long tails. Like frogs and toads, their skins have no scales and their toes have no claws. However, salamander larvae have external gills instead of internal gills like frog and toad tadpoles. The gills on young salamanders are feathery projections just behind the head.

Salamanders seldom wander from water, because their skins need more moisture than frogs and toads. Some are slightly slimy, but their skins usually are only cool and damp.

Salamanders are harmless creatures; their main protection comes from secretive habits. If they seem to resist being handled, it is probably to escape from the light, and from the hot, dry hand that holds them.

People once thought salamanders came from fire, or could endure flames. This fallacious belief probably came from the fact that salamanders sometimes crawl into damp wood, or under bark, to hide. If a piece of this wood were put on a fire and heated, any salamanders hiding in it would come out soon. To a person who did not know that these creatures had crawled in the wood to hide, it might seem that they came from the fire. This old belief that salamanders came from fires has even extended to common names for portable heaters. Builders who use sheet metal heaters to dry out newly plastered buildings refer to them as salamanders. Remember, though, that salamanders do not like heat. In fact, hot dry surroundings can kill these cold-blooded creatures quickly.

Most salamanders are appealing little animals that soon become accustomed to captivity in a well-prepared terrarium. They do not sing, they do not bite people, and they are nonpoisonous. They do eat quantities of insects and other small invertebrate animals. Because of their interesting habits, gentle nature, and wide distribution throughout the eastern and northern United States, they merit our study and appreciation.

Skin

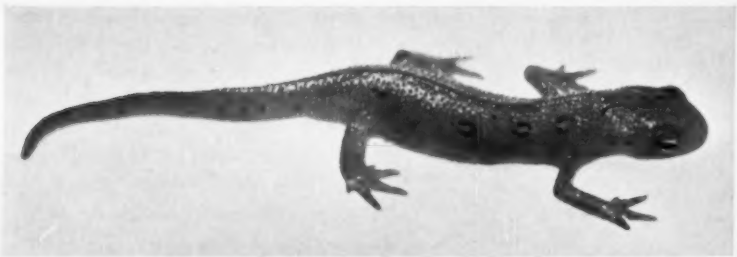
The skin of salamanders is nearly always smooth, and not warty as it is in some toads. In the newt, one of the most common salamanders, it is slightly granular in texture and somewhat dry, but in nearly all others it is smooth and moist like a freshly peeled hard-boiled egg.

Salamanders have much more brilliantly colored skins than do most frogs and toads. The red eft, an immature stage in the newt, has a bright orange-red or vermillion color. You can often find red efts crawling along the woods floor near a pond after a summer rain.

The spotted salamander is black with yellow dots scattered over its body. The tiger salamander is even more brilliantly marked with yellowish splotches against a black background. The marbled salamander has paler splotches of almost gray-white color against a dark background.

The red salamander is perhaps the most striking of all our eastern amphibians. Its background color is bright orange, or coral-red, with black spots scattered over its body. It inhabits cold springs and clear streams in wooded areas. Its flashy colors are sure to surprise the novice rummaging under wet stones for animal life. Some persons think that such a brightly colored creature with its moist, smooth skin must be harmful, but of course it is not.

The slimy salamander is a species



After about a year on land, this red eft returns to water, even though it has lost its gills. It remains in or near water for the rest of its life as a newt.

Nearly all the details of the adult Jefferson salamander are visible in its shed skin.

with very active slime glands in its skin. This salamander is dark, slaty gray or black, with tiny flecks of silver scattered over its body. It is especially sensitive to changes in humidity, and uses its active mucous glands to help keep its skin moist.

In one family of salamanders, the Plethodontidae (*pletho* coming from the word meaning full, and *dont* from the word for tooth), the adults have no lungs. These salamanders have only the lining of the mouth, and a skin full of tiny capillaries, to help them get oxygen. For them, it is especially important to keep the skin moist. If their skin dries out, they suffocate.

One of the most common plethodontid salamanders is the shy, red-backed salamander. This slender creature is often turned up under rotting logs or stones in damp woods. Its back is rusty colored, shading to dark gray at the sides and light gray underneath. Because it is so cute and delicate looking, people who find them handle them more than is good for the creatures. Whether lunged or lungless, salamanders prefer cool, moist locations even more than frogs and toads. Their skins demand it.

Salamanders, like frogs and toads, occasionally shed and eat their skins. The skin is shed in one piece, splitting down the back and then passing off the body like a glove being turned inside out. Occasionally, a shed skin is not eaten immediately, and can be retrieved by a human. Ordinarily, however, the salamander turns and eats the skin, sometimes even before it is completely shed.

Mouth

The mouths of salamanders may have many very small teeth. In fact,

the teeth of most are so small that you would not see them unless you looked with a magnifier. Some teeth are located in clusters on the roof of the mouth. The teeth probably help in holding slippery prey such as small worms, but are not used in chewing as are the teeth in most mammals.

The tongues of salamanders, although somewhat sticky, do not all shoot out for food as do the tongues of frogs and toads. Salamanders usually seize their food by their jaws. The tongue of the red salamander, however, is mushroom-shaped and is attached at its center. It can be projected some distance from the mouth to snatch food. The tongues of other salamanders remain in the mouth.

The lining of the mouth in plethodontid salamanders is rich in small blood vessels and here much of their breathing is done. Air circulating around this moist lining supplies these capillaries with oxygen. These salamanders use their mouth lining just as we make use of our lungs.

Eyes

The eyes of salamanders resemble those of frogs and toads, but may not be set so far above the head. Like frogs and toads, salamanders seem to be more attracted to moving prey than to stationary prey. Their ability to focus on nearby objects may be better developed than in some frogs and toads, because salamanders cannot snatch their prey from such a distance.

Look closely at the eyes of a salamander such as the newt. Can you see a resemblance to the eye of the toad? The same gold iris, dark pupil, and golden cords of muscle surrounding the pupil are evident. The eyes of these creatures, when seen close up, are marvelous and beautiful structures.

Ears

Salamanders lack the hearing apparatus that is so well developed in frogs and toads. There is no external tympanum like the one that is visible in the frogs and in the American toad, nor is there a cavity behind the skin where the tympanum would be. Some vibrations seem to be sensed through the front legs, but salamanders do not seem to hear sounds carried in the air. They may be sensitive to footfalls, but not to voices.

Breathing

As you have already read, salamanders may breathe by means of lungs, by the help of their moist skins, or through the lining of their mouths. Adults of the newt and larger salamanders such as the tiger salamander, the spotted salamander, and the Jefferson's salamander, all have lungs and come to the surface of the water for air or live on land.

The family of lungless salamanders (Plethodontidae) including the two-lined salamander, the red-backed salamander, the red salamander, and the purple salamander have no lungs as adults. They depend upon

their moist skins and upon the blood-rich lining of their mouths for their oxygen.

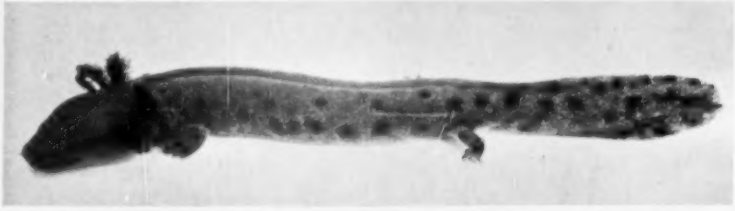
The lungless two-lined salamander spends most of its adult life in or very close to clear, cold streams. Because cold water can hold more oxygen than warm water, this creature can get plenty of oxygen as long as it lives in the cold water of a rippling stream. In an aquarium where the water is warm and not very rich in oxygen, it may suffocate.

Larval salamanders have gills that are visible almost as soon as the young leave the egg membranes. These feathery gills are richly supplied with blood vessels, especially at their tips. Here the oxygen in the water diffuses into the blood and gets carried to all parts of the body.

If you want to see blood circulating in the tips of the gills, place a larval salamander in a weak solution of chloretone for a few minutes until it ceases to wriggle when touched along the tail. Remove it from the chloretone, put it in fresh, cold water, and set it under a microscope. Even under fairly low power, you can see the corpuscles in the capillaries near the tips of the gills get squirted along with each heart beat.

As metamorphosis (changing from larva to adult) begins in late summer, the gills slowly decrease in size, and the skin, or lungs, or both take over the breathing process. Some salamanders, however, never lose their gills. The spotted salamander is one that sometimes fails to lose its larval characteristics, and keeps its gills throughout its life. Retaining larval characteristics throughout life is called *neotony* (nee-ah'tony), and occurs at times in several species of salamander.

One salamander that retains its gills as an adult is *Necturus*, commonly called the mud-puppy. This large salamander reaches a length of nearly one and a half feet, although its average length is nearer one foot. The gills of *Necturus* are large and feathery and well able to supply this big salamander with oxygen from large streams and lakes where it lives.



Necturus retains its gills for life, a condition known as neotony. It can reproduce even though it is just a big larva.

Tail

The tails of salamanders are used principally for propelling them in water. On land, the tail may help to balance the animal when it leaps, or to turn it over when it falls off a stone or log. Perhaps the tail also acts as an energy reservoir when food is scarce.

The tails of the larvae are flattened, and have a thin, membranous keel above and below the central, cartilaginous portion. With these tails, they can swim rapidly through the water, catching small prey that swims or wriggles past them.

When the larvae transform to adults, their tails become round and thick at the base. For land salamanders, there is no need for the oar-like tail that they had as larvae. For those that stay in the water as adults, the tail remains flattened and continues to serve as an oar.

In newt courtship, the male clasps the female tightly around the neck with his hind feet, then rubs his chin against hers — an odd courtship compared to higher animals!

HABITS OF SALAMANDERS

Courtship and reproduction

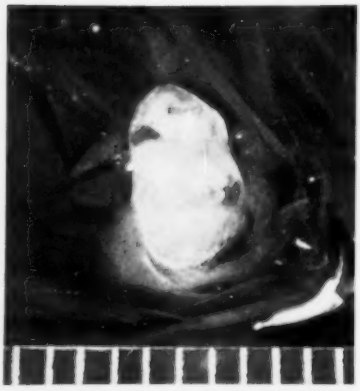
Salamanders often exhibit a much more complicated pattern of courtship than do frogs and toads. The common newt, for example, goes through an elaborate courtship before mating takes place. The male seizes the female with his hind legs just behind her head, in an almost choking manner, and then begins an elaborate chin-rubbing and twisting. These complicated movements go on for many minutes, after which the male leaves the female and goes to deposit spermatophores on the debris of the pond bottom. The female follows, picking up the sperm clumps to fertilize her eggs.

Each male lays many spermatophores. The spermatophores look like little white or cream colored cones of jelly, from pin-head size to match-head size. You can see them on the vegetation of shallow, woodsy ponds in early spring. On top of these little cones is a clump of sperm which the female lifts off and takes into her body.

At the base of the female's tail is her cloaca (clow-ay'cuh), which is the opening for both waste and eggs. It is with the edges of the cloaca that she lifts off the sperm cap. With

this sperm cap inside her body, fertilization of the egg is accomplished. In this process, salamanders differ from frogs and toads. In frogs and toads fertilization is external, the male depositing the sperm on the eggs as they are laid. In salamanders, it is internal.

The female salamanders lay their eggs singly or in clusters on bits of submerged vegetation, on twigs, or on the underside of stones. Spotted salamanders lay their eggs in clusters of about a hundred. Each egg is about 1/8 inch in diameter, and is in a gelatinous ball about 1/4 inch in diameter. The whole mass looks like jelly. Often it becomes greenish



This spermatophore of a spotted salamander looks like a tiny white clump on the pond bottom. Each mark represents one millimeter.

A spotted salamander and its spermatophores. How many can you see in this photograph? One will fertilize all the eggs that a female can lay.

When this twig was picked up from a woody pond a cluster of spotted salamander eggs clung to it.

colored from a coating of green algae. These algae do not hinder the development of the eggs; some scientists think the algae may actually help the eggs.

The spotted salamander is one of the earliest to lay eggs in the spring, often arriving at the pond before all the ice is gone. They are most active at night. With the aid of a flashlight you may see these large salamanders roving over a woodsy pond bottom, courting or laying eggs.

The newt deposits its eggs one at a time on the vegetation of a pond or aquarium. The red-backed salamander deposits eggs in clusters on the underside of well-rotted logs, or in cavities under decaying stumps. The eggs resemble tiny pearls and are often confused with the eggs of slugs. The mud-puppy and the two-lined salamander deposit their eggs on the underside of stones in streams or fresh-water ponds. The tiny four-toed salamander nearly always deposits its eggs in the sphagnum moss of swamps, just above the water-line. Regardless of where the eggs are laid, they must be in water, or in a place where there is plenty of moisture. If they dry out, they will not hatch.

Growth and metamorphosis

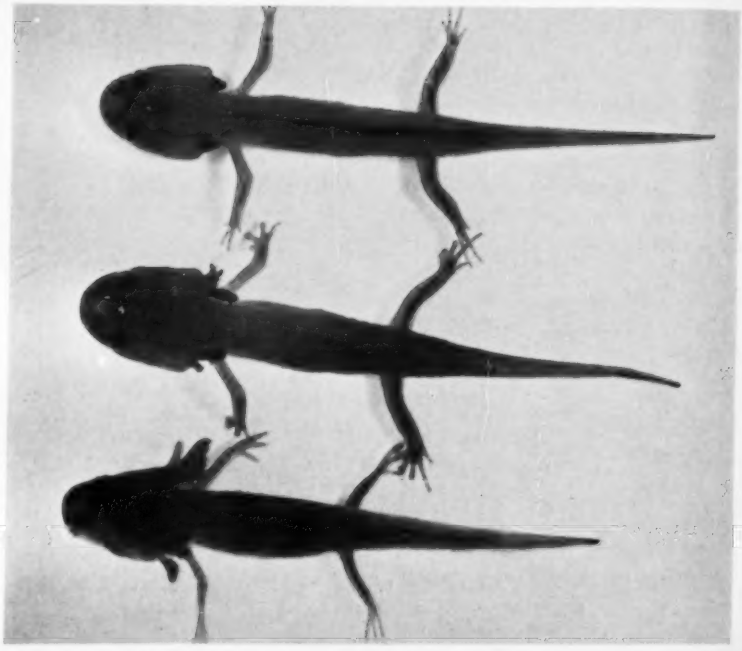
As the young larvae grow inside the egg membranes, they resemble the tadpoles of frogs and toads. You can soon see, however, that these tiny salamander larvae have projections at the sides of their heads. At first, these projections are of two kinds. One is just a balancer made of cartilage. Its function is like the guard wheels on a youngster's bicycle; it keeps the larva from tipping over on its side when it first begins to swim. In a few days, the larvae is better coordinated, and the balancers disappear.

The rest of the projections at the side of the head are the gills. These external gills are so easy to see that they are excellent for studying circulation (page 23). These gills are responsible for the respiration of the larva until metamorphosis takes place, some time in later summer.

Salamander larvae also develop legs soon after hatching. Within a few weeks, most salamander larvae have four feet, with distinct toes on each foot. Much of their locomotion then is by creeping, except that the oar-like tail is used to swim quickly from one place to another.

Salamander larvae are extremely voracious. They eat smaller animals such as *Daphnia*, *Cyclops*, mosquito wigglers, worms, and similar invertebrate animals. They approach food by slow, stealthy crawling. Then suddenly their jaws open and the food is swept into their mouths in one lightning gulp.

The larvae appear to chew their food, although their jaw movements are mostly to press the food together and arrange it for swallowing. It is amazing how these little water tigers can handle such large pieces of food, sometimes eating so much that their stomachs actually bulge.



As a salamander larva changes to an adult, its gills shrivel and disappear as shown here. The process takes several days.

Salamander larvae are so fierce they often attack each other, especially when crowded together. Then they may nip at each other's gills or legs. It is not uncommon to see larvae of spotted or Jefferson's salamanders with missing legs or gill filaments because of clashes with other salamander larvae.

A missing leg is not a catastrophe for a salamander larva, for these animals have remarkable powers of regeneration. Although they do not often grow a whole limb back just as it was, they can replace most of a missing limb if it is removed while they are young. Higher animals do not have this degree of regenerative power.

When the larvae are fully grown, usually at the end of their first summer, their gills begin to atrophy (a'tro-fee, meaning wither). Their skins or new lungs take over the task of respiration, and within a few days the gills have lost their function

as breathing organs. From now on, the salamander is amphibious. It can live either on land or in the water. If it is a lunged salamander such as the newt, the spotted salamander, or the tiger salamander, it usually must get air from above water. If it is a lungless salamander such as the two-lined salamander, the red-backed salamander, or the slimy salamander, it may be content to seek out a moist place beneath a stone or a log, or it may stay in or at the edge of a stream.

Feeding habits

Salamanders are primarily carnivorous creatures. As larvae, they feed on all sorts of small aquatic invertebrate animals. As adults, salamanders feed on insects, worms, slugs, spiders, sow bugs, and similar animals. The larger salamanders such as *Necturus* feed on crayfish, minnows and insects. Occasionally *Necturus* even eats plant material. The largest of our salamanders, *Amphiuma*, sometimes called the Congo eel, even eats snakes, frogs, and large minnows. This salamander is large enough to give a good bite, but unfortunately it does not live in the northeast. Its range is restricted to the Gulf states and lower Mississippi valley.

In searching for food, salamanders seem to be slow and deliberate in their movements, preferring to let food come to them rather than seeking it out. This is especially true of aquatic forms. Land forms such as the red-backed salamander may wander about after dark searching for food, but the searching is also done slowly and deliberately. Salamanders seldom hurry to their dinner table.

Hibernation

Land salamanders usually hibernate under decaying stumps, around the roots of trees, in a well, or almost any place that will remain above freezing and still be damp. They seek out their hibernating places in autumn, before the nights are frosty, and then emerge in the spring when the snow is gone.

The spotted salamander and Jefferson's salamander (named for Thomas Jefferson who was first to study and describe it in detail) come out of hibernation very early, often in late February or early March. Others come out a little later; the red-backed salamander is one of the latest to leave its punky log.

Aquatic forms such as the ugly-looking but harmless hellbender, the two-lined salamander, and *Necturus* (the mud-puppy), are active all winter so long as the water does not freeze. Like the fish around them, they are cold-blooded and do not need to maintain a high body temperature to live.

Keeping Salamanders indoors

Salamander eggs and larvae can best be kept in shallow enamelled pans of pond water. They do not need deep water in which to live—only enough to cover them and provide a place for their natural food

to live. Because larvae like to hide under things during the daytime, provide enough vegetation, sticks, or leaves for them to get under when they wish. By adding fresh pond water daily, you can usually introduce enough small organisms to keep the larvae well fed. Small bits of raw meat, or bits of earthworm also make good food. Remove whatever is not eaten within an hour or so to keep the water from being fouled.

In a well-planted and moist (*not soggy*) terrarium, you can keep the red-backed salamander, spotted salamander, newt, or dusky salamander. The larger salamanders will probably dig up the terrarium and you will have a difficult time keeping it neat, but the smaller ones do not disturb the plantings. Feed these creatures earthworms, insects, spiders, and whatever small invertebrates you can find. If they are well fed and housed, salamanders make good pets and cause little trouble. If you keep only native ones, you can always free them when it becomes too much trouble to keep them.

In reading about salamanders and studying their habits, you may learn to appreciate them because they eat insects. You may like them because they make such good animals for classroom study. Like people, however, you will probably like them best when you know them best.

HELPFUL REFERENCES

For the pupil

HARRIS, L. D., AND HARRIS, N. D., LITTLE RED NEWT, *Little, Brown and Company, Boston, 1958. 57 pages.* The life story, told in flashbacks, of a red eft that went to school and lived in a classroom terrarium. Intermediate.

HOGNER, DOROTHY, FROGS AND POLLIWOGS, *Crowell Company, New York, 1956. 63 pages.* Brief descriptions of the structure and life history of selected species of frogs and toads, with a short section on how to keep them. Intermediate.

MCCLUNG, ROBERT M., BUFO, THE STORY OF A TOAD, *William Morrow, New York, 1954. 48 pages.* The life history of a farm toad, punctuated by frequent brushes with predators and other animals. After hibernation there, *Bufo* returns to the pond in spring to sing with other toads. Primary.

SEARS, PAUL M., TREE FROG, *Holiday House, New York, 1954. 46 pages.* The life story of a tree frog, from the time that the adult tree frog emerges from hibernation until one of its own young leaves the tadpole stage and itself hibernates for winter. Primary, intermediate.

ZIM, HERBERT, AND SMITH, HOBART, REPTILES AND AMPHIBIANS, *Simon and Schuster, New York, 1956. 157 pages.* A pocket-sized, but fairly complete field guide to the common species of North American reptiles and amphibians with additional information on how to collect and keep them. Upper.

For the teacher

BISHOP, SHERMAN, HANDBOOK OF SALAMANDERS, *Comstock Publishing Company, Ithaca, New York, 1947.* Complete handbook, with numerous documentations, of the salamanders of the United States and Canada. Includes excellent descriptions, life histories and range maps.

BISHOP, SHERMAN, THE SALAMANDERS OF NEW YORK, *State Museum, Albany, New York, 1941. 359 pages.* Detailed accounts of the appearance, life histories, and distribution of salamanders native to New York State.

CONANT, ROGER, A FIELD GUIDE TO REPTILES AND AMPHIBIANS, *Houghton Mifflin Company, Boston, Massachusetts, 1958. 352 pages.* An excellent field guide for teacher or beginner, with identification hints, life histories, and copious illustrations in color. It also includes range maps, and directions for collecting.

OLIVER, J. A., NORTH AMERICAN AMPHIBIANS AND REPTILES, *Van Nostrand, Princeton, New Jersey, 1955. 334 pages.* A generalized, non-technical account of reptiles and amphibians. Includes good photographs, several food charts, and excellent sections on feeding, reproduction, and locomotion.

POPE, CLIFFORD, AMPHIBIANS AND REPTILES OF THE CHICAGO AREA, *Chicago Natural History Museum, Chicago, Illinois, 1947. 266 pages.* Clearly and interestingly written life histories of many of the species of amphibians found in the Northeast.

WRIGHT, A. H. AND WRIGHT, A. A., HANDBOOK OF FROGS AND TOADS, *Comstock Publishing Company, Ithaca, New York, 1949. 621 pages.* Probably the most complete single-volume handbook on tailless amphibians. Contains many field observations and data on size, distribution, feeding habits, reproduction, and general ecology.

A CHECKLIST OF NEW YORK STATE AMPHIBIANS

Frogs

Cricket frog (SE, SW)*	*Acris gryllus*
Peeper	*Hyla crucifer*
Tree frog	*Hyla versicolor*
Bullfrog	*Rana catesbeiana*
Green frog	*Rana clamitans*
Pickerel frog	*Rana palustris*
Meadow frog	*Rana pipiens*
Mink frog (Northern)	*Rana septentrionalis*
Wood frog	*Rana sylvatica*
Sphagnum frog (SE)	*Rana virgatipes*

Toads

American toad	*Bufo americanus*
Fowler's toad (SE, mostly Long Island)	*Bufo woodhousii*
Spadefoot toad (SE, mostly Long Island)	*Scaphiopus holbrookii*

Salamanders

Jefferson's salamander	*Ambystoma jeffersonianum*
Spotted salamander	*Ambystoma maculatum*
Marbled salamander (SE)	*Ambystoma opacum*
Tiger salamander (SE)	*Ambystoma tigrinum*
Hellbender (Southern, western rivers)	*Cryptobranchus alleganiensis*
Dusky salamander	*Desmognathus fuscus*
Alleghany salamander (Central and southern)	*Desmognathus ochrophaeus*
Two-lined salamander	*Eurycea bislineata*
Long-tailed salamander (Southern, SE)	*Eurycea longicauda*
Purple salamander	*Gyrinophilus porphyriticus*
Four-toed salamander (Central southern)	*Hemidactylium scutatum*
Red-backed salamander	*Plethodon cinereus*
Slimy salamander (SW, southern)	*Plethodon glutinosus*
Wehrler's salamander (SW)	*Plethodon wehrlei*
Red salamander (Southern)	*Pseudotriton ruber*
Mud-puppy	*Necturus maculosus*
Newt	*Triturus viridescens*

* Parenthetical sections refer to New York State only.